COMMENTARY

Responsible and Ethical Conduct of Research Training for Undergraduate Researchers

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Abstract

Responsible conduct of research (RCR) is a crucial aspect of research ethics that applies to everyone involved in research. While RCR training is often emphasized for graduate students and postdoctoral researchers, many institutions and funding agencies require undergraduates to complete it, particularly if they are supported by federal grants. RCR training for undergraduate students can sometimes be overlooked, as their involvement in research is not as prominent or numerous as that of graduate students or postdoctoral researchers.

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"RCR is the practice of scientific investigation with integrity. It involves the awareness and application of established professional norms and ethical principles for all activities related to scientific research" (NIAID 2022). The goal of responsible conduct of research (RCR) training is to promote a culture of integrity, prevent misconduct, and ensure the public's trust in scientific progress.

Undergraduate researchers (UGRs) may be involved in research that requires them to handle data, work with human and animal subjects, collaborate with others, and contribute to publications. RCR training can help UGRs understand their responsibilities, prevent misconduct, navigate ethical dilemmas, understand authorship, and prepare for future careers. The earlier in their academic career that UGRs can be exposed to RCR concepts, the stronger their foundation in scientific pursuits.

If a faculty mentor/adviser is unable to spend the time with their undergraduate researchers to educate them on these topics, the researcher is vulnerable, and this vulnerability could be exploited to their detriment. Undergraduates involved in or seeking involvement in research should pursue RCR training opportunities at their institution to ensure they are prepared for the ethical challenges of scientific investigation. Oftentimes, information about RCR training and resources can be found through an institution's undergraduate research office, research compliance and integrity office, institutional review board office, or a similarly titled office. UGRs at any institution are free to contact these offices for guidance on general RCR training and specific RCR topics. An institution of higher education should staff an office of research integrity (or similar) that serves to support the institution's research community through training on ethical research practices and investigation of reported researcher misconduct.

At a minimum UGRs should know with whom they should communicate in a number of research-related scenarios, know which offices to consult for additional guidance, and know if their institution has an anonymous whistleblower program.

The body of this commentary will address each RCR topic and offer "UGR keys" that undergraduate student researchers should be aware of with respect to each topic. These keys describe potential pitfalls for UGRs and what they can do to avoid them through self-advocacy.

Requirement for Undergraduate Researchers

Many institutions have their own RCR training requirements, often in accordance with funding agencies like the National Science Foundation and the National Institutes of Health. If an undergraduate student is supported by a grant from one of these agencies, RCR training is mandatory. The training can take various forms, including online courses, in-person workshops, seminars, or a combination of both.

In-Person versus Online

Online training is accessible and can be completed by UGRs at times convenient to their course load, and the material can be referenced easily if needed. However, a drawback to online training is that the UGR could skip through the training without truly absorbing the material. This can be remedied by including required knowledge checks or quizzes at the end of each module.

In-person training offers a more hands-on approach to the topics. Often, senior faculty and administrators will present the material and be able to provide anecdotes that are specific to the UGR's institution. These dedicated workshops or bootcamps can range from one or two days with morning and afternoon sessions or could be integrated into required coursework, ensuring that no student misses the material.

RCR Topics

Research Misconduct

Understanding what constitutes fabrication, falsification, and plagiarism, and the policies for handling misconduct.

The Office of Science and Technology Policy defines research misconduct as "fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results" (Federal Research Misconduct Policy 2000). Institutional research misconduct policies must provide clear guidance regarding the definition of misconduct in research, the procedures in place for reporting and investigating misconduct, and provide protections for whistleblowers and those accused of misconduct. The Office of Research Integrity outlines three key areas for addressing and handling research misconduct:

Reporting and Investigation. "Federal misconduct policy assumes that researchers and research institutions bear the primary responsibility for reporting and investigating allegations of misconduct. This assumption is consistent with the position, strongly supported by most researchers, that research is a profession and should regulate its own conduct" (Steneck 2007).

Self-Regulation. "Successful professional self-regulation depends on conscientious community participation. For individual researchers, this means they must assume responsibility for their own actions, take misconduct seriously, and report apparent misconduct by other researchers. Every institution that receives Public Health Service (PHS) funding must have procedures in place for receiving and investigating reports of research misconduct. Researchers should be familiar with these procedures and their institution's definition of research misconduct" (Steneck 2007). Researchers may jeopardize their careers if they commit misconduct, intentionally or otherwise.

Protections. "Research institutions and researchers must not in any way penalize or take action against individuals who report research misconduct in good faith. Even if accusations are not sustained, as long as they are brought in good faith, informants must be protected and given support since they play a vital role in professional self-regulation" (Steneck 2007).

UGR Keys

Undergraduates who are not aware of these responsibilities and protections are at risk of inadvertently derailing their academic or professional careers. Research misconduct policies should be included as part of UGR onboarding. The role of the faculty advisor is important here as the UGR needs an established researcher to lean on and trust. Additionally, the UGR should be made to feel empowered to act as required according to federal and institutional research misconduct policies, even if it means reporting their faculty advisor or other mentor. Their awareness of federally mandated protections is important, as failure to report misconduct can be considered a crime.

Human and Animal Subjects

The ethical principles and regulations for research involving human participants and laboratory animals.

Human Subjects

Institutions that intend to submit proposals for and receive federal funding for research involving human subjects must enter into a Federalwide Assurance (FWA) with the Office of Human Research Protections. The FWA is an agreement between the institution and the U.S. Department of Health and Human Services that commits the institution to comply with 45CFR46 (Protection of Human Subjects 2018). This part of the Code of Federal Regulations outlines the requirements an institution must have in place in order to review and approve the conduct of human subject research (HSR). For example, this could include establishing and maintaining an institutional review board (IRB), criteria for HSR approval, criteria for properly obtaining or waiving informed consent, and so forth (University of Maryland College Park IRB 2025).

Investigators engaged in HSR at an institution with an FWA must comply with all relevant federal regulations, local laws, and institutional policies related to the protection of

human subjects. UGRs should know when they are engaged in HSR and should receive training in HSR protections. If additional guidance is needed in this area, the UGR should reach out to their institutional IRB office (or equivalent) or IRB chair/vice chair as a resource (University of Maryland College Park IRB 2025).

Animal Subjects

"The use of animals in research, testing, and teaching is primarily governed by two federal laws and the associated regulations, policies, and guidelines: The Animal Welfare Act (AWA) and the Animal Welfare Act Regulations (AWR) and the Health Research Extension Act (HREA) with the associated PHS Policy on Humane Care and Use of Laboratory Animals (PHS Policy, 1985) and the Guide for the Care and Use of Laboratory Animals (1962, 2011, 8th ed.)" (University of Maryland College Park IACUC 2025).

Researchers who use animals in research should be familiar with both laws. It is important to note that researchers are not permitted to make an independent determination about whether their animal research protocol is covered or excluded. This is the charge of the Institutional Animal Care and Use Committee. "The IACUC oversees and evaluates all aspects of the institution's animal program, procedures, and facilities" (Steneck 2007, The Welfare of Laboratory Animals). Researchers are encouraged to consult with the IACUC and/or the IACUC support staff in advance of starting work in an animal facility or being added to an animal use protocol.

Institutions that allow research involving animals will have a training requirement for investigators and their research team members. This training will typically need to be renewed every few years if the researcher remains engaged in animal research. The IACUC office will review training records to ensure that the researchers listed on the project have met institutional requirements.

UGR Keys

UGRs should be aware of their institutional support offices that manage these compliance functions. A situation may arise where the UGR must report a deviation, adverse event, or a separate instance of noncompliance with the approved research protocol. These instances should be managed by the principal investigator or lead researcher, but if this is overlooked or intentionally not reported, the UGR has a responsibility to reach out to a compliance officer within the IRB or IACUC offices. The staff in these offices typically hold a wealth of knowledge on proper regulatory practices, training requirements, and reporting and managing adverse events/incidents. They also usually have an existing relationship with the office of general counsel, the office of research integrity (or equivalent), and the vice president for research (or equivalent). If a UGR is having difficulty communicating issues regarding their mentor relationship through established channels, a compliance officer may have enough "capital" to bend the ear of the right person while maintaining anonymity and/or confidentiality of the UGR/mentee bringing the concerns (University of Maryland College Park COI 2025).

Conflicts of Interest

Recognizing and managing personal, professional, and financial conflicts that arise in research.

Through the Bayh-Dole Act of 1980, researchers and institutions are allowed to retain ownership of their inventions and are encouraged to commercialize their work (Bayh-Dole Act 2011). This presents a strong incentive to continue making discoveries, and distinctive accomplishments will help to bolster a researcher's profile and standing in their field. However, this can increase the potential for malfeasance, as the researcher has ample opportunity to bias or exaggerate results that could be beneficial for profiting from an invention or discovery. This creates the potential for a real or perceived conflict of interest (COI). A COI should not be avoided, nor should it have a negative connotation, as eliminating it entirely may stymy an opportunity to advance the science in a particular area. It should, however, be properly identified, disclosed, and managed.

UGR Keys

Typically, COIs are tied to the principal investigator or lead researcher, but UGRs and graduate researchers can also have COIs. If a UGR has a company that stands to benefit from a research project that they are a part of, this COI must be disclosed, and a management plan may need to be established to mitigate the real or perceived conflict. This COI could be financial in nature, the use of intellectual property, or the potential to manipulate data to make the company look better for outside investors. Identification and disclosure of the conflict is always the first step. Proper management of this COI should be discussed with the UGR's mentor and the institution's COI office staff or COI officer. If a COI cannot be avoided, there are multiple ways to manage a conflict, and these methods are dependent on the issues the conflict presents. Components of a management plan may include keeping the UGR responsibilities separate from data collection or analysis or identifying an oversight official to periodically review results to ensure the validity of the data. It is important to remember that COI management is determined by research administrators and COI committees or officers, not the researchers themselves.

Alternatively, the UGR must be provided with situational awareness of any COIs or COI management plans the principal investigator, lead research, mentor, or collaborator might have. A lack of transparency regarding these actors' potential COIs increases the risk of deception and abuse.

It also places the UGR in a vulnerable position where they could unknowingly facilitate this abuse. UGRs and any other research team members should not act on a directive that is outside of the approved management plan. It is important that the UGR and any members of the research team know that they can contact the COI office or officer to confirm the COI management plan criteria or report noncompliance with the criteria without retribution.

Data Management

Data management practices include proper methods for data acquisition, recordkeeping, retention, sharing, and ownership.

Data Integrity

"The integrity of data and, by implication, the usefulness of the research it supports, depends on careful attention to detail, from initial planning through final publication" (Steneck 2007, Data Management Practices Introduction).

Data Ownership

The requirements of sponsors and funding agencies can differ, and researchers must be aware of their responsibilities to them prior to commencing data collection. For instance, if the sponsor or funding agency requires the researcher to send human subject data to an open science repository, the consent language should inform the participant that this will happen. It is important to note that research support funding is typically awarded to research institutions and not directly to the researchers. Institutional signature authority usually rests with the researcher's institutional research administration office (or equivalent); therefore, researchers should not sign or enter into agreements that affect the control and use of data (Steneck 2007, Data Ownership). The resources and expertise within the research administration office can identify and confirm the data ownership, publication rights, and any additional obligations.

Data Storage and Confidentiality

Responsible handling of data begins with proper storage. Consultation with a faculty advisor or lab manager should be able to provide the UGR with the resources needed to limit access to those who need it and to protect the confidentiality of data to a reasonable degree.

UGR Keys

Proper data collection and storage may seem like common sense, and to many UGRs, this is likely the case. However, observing established researchers and faculty mentors implement appropriate procedures will help the UGR build a foundation as a responsible principal investigator in the future. Being involved in the data authorization process, such as through IRB or IACUC review, provides experience in ethical review and highlights the importance of proper data collection to ensure scientific validity. The UGR not only learns proper data collection and management practices as an individual but also learns how to pass this knowledge on to a lab manager or other undergraduate or graduate research assistants.

Mentor/Mentee Relationships and Healthy Research Environments

The roles and responsibilities of both in a research relationship.

Mentors bring the knowledge and skills that an inexperienced researcher needs to learn. Mentorship is primarily the responsibility of the faculty advisor, but this is sometimes delegated to a less-experienced graduate student. While it is ideal that the faculty advisor provides direct mentorship, many graduate student researchers also have experience in RCR and will have learned from the faculty advisor. A UGR should feel comfortable seeking guidance from graduate researchers, as they are typically only a few steps ahead in their academic careers and likely remember their experiences as student researchers. "Good mentoring should begin with a clear understanding of mutual responsibilities, a commitment to maintain a productive and supportive research environment, proper supervision and review, and an understanding that the main purpose of the relationship is to prepare trainees to become successful researchers" (Steneck 2007, Mentor and Trainee Responsibilities Introduction).

Trainees or mentees are individuals learning to become researchers under the guidance of an established researcher. They can contribute both effort and fresh perspectives. Before accepting a position in a lab or research program, they should be aware of their responsibilities to their mentors. Research contracts can help establish clear roles and responsibilities, identify resources, and set clear expectations. They also provide a point of contact. These responsibilities can include time commitment, methods of evaluation, division of labor, standard laboratory procedures, following regulations and approved protocols, and so forth (Mabrouk 2003).

UGR Keys

UGR mentees should receive written guidance on the laboratory's authorship and publication practices. They should be aware of potential bias or favoritism on the part of the mentor, as each researcher, even in a competitive environment, should be treated equally and not placed at a significant disadvantage. Mentees should observe and expect professionalism from their mentors. If the opposite is observed, the UGR should feel comfortable discussing this with their mentor or have an outlet within the department to bring up their concerns without fear of reprisal/retribution. On the other hand, UGRs should not abuse departmental resources if their concerns are unfounded or exaggerated.

"Mentors may not directly review all of the UGR/mentee's work directly as there may be a supervisory structure that includes post-doctoral students, graduate students, or laboratory managers that handle these responsibilities" (Steneck 2007, Supervision and Review). However, the UGR should request a standardized, scheduled one-on-one meeting time with their mentor at a reasonable time. For instance, a director may report to an associate vice president but only meet directly with them once every other week. However, the director has a direct line to the associate vice president if an issue arises that requires their attention or immediate situational awareness. Maintaining a standing meeting with their mentor allows the UGR an opportunity to discuss progress and areas for improvement. It is also an opportunity for the UGR to maintain accountability of their mentors' involvement in their development.

Collaborative Research

Ethical considerations when working in teams or with other institutions.

Effective collaboration begins with a clear understanding of roles and relationships. Before work begins, there should be a common understanding of project goals and expected outcomes; investigator roles and responsibilities; data collection, storage, and access; publication responsibilities; authorship criteria; reporting responsibilities; intellectual property ownership; and dispute resolution (Steneck 2007, Roles and Relationships). The principal investigators or lead researchers in a collaborative research arrangement will need to ensure that proper training is completed by both research teams. This should include awareness of formal agreements regarding material transfer, handling of hazardous materials, and compliance requirements—whether institutional, federal, or both.

UGR Keys

The mentor should lead by example when addressing this RCR element. By allowing the UGR to observe the steps that establish a healthy collaborative relationship with other researchers, the mentor provides a foundational model for the mentee. The UGR should be observant during the creation of a collaboration, as they may be able to identify disputes or challenges in this process. The UGR should consider what could be done differently in those situations to further develop a strong relationship with the collaborator. A primary key for a successful collaborative research relationship is effective communication. Principal investigators and co–principal investigators can be involved in multiple components of the research process and may not include communication as a top priority. If resources allow, each research team should identify a point of contact for communication to ensure that messages are going through and not missed. This can be especially helpful if unanticipated problems arise on one or both sides of the collaboration.

Authorship and Publication

Ethical practices for determining authorship, acknowledging contributions, and avoiding plagiarism.

"Authorship is generally limited to individuals who make significant contributions to the work that is reported. This includes anyone who: was intimately involved in the conception and design of the research, assumed responsibility for data collection and interpretation, participated in drafting the publication, or approved the final version of the publication" (Steneck 2007, Authorship).

However, this can vary depending on the discipline and the journal. It is important that the UGR is aware of the criteria used to determine who should receive credit and be listed on publications as contributing. Without knowledge of these rules, it is possible that the UGR could be excluded from receiving proper credit for contributions to the published work.

Primary Author

"Many journals now require one author, called the corresponding or primary author, to assume responsibility for all aspects of a publication. This includes listing the names of all authors" (Steneck 2007, Authorship).

UGR Keys

Collaborative authorship is more effective when a mutual understanding is established at the outset of a research partnership. Several years ago, the APA Science Student Council developed guidelines for graduate students that feature practical and straightforward tools (APA 2006). These resources help clarify the requirements for authorship and assist in determining the hierarchy of authorship among collaborators.

Oftentimes, the primary author will be a tenured faculty member or experienced graduate student. The UGR should be aware of who has been identified as the primary author and discuss this with their mentor. Having an advocate is key to the UGR receiving fair acknowledgment of their contributions. If the UGR does not qualify as an author but has provided support, the primary author has the responsibility to recognize this support in the acknowledgments section of the publication.

UGRs should be aware not to be pressured to provide "honorary authorship" to someone undeserving of this recognition, as this is unethical and violates scientific integrity. This could be someone who served as a mentor or provided funding, or a department chair. While these individuals may have contributed guidance or resources, they would not be considered authors.

Peer Review

The importance of confidentiality and objectivity in the peer review process.

Peer review is an evaluation by colleagues with similar knowledge and experience. These reviewers are obligated to preserve confidentiality throughout the review process if this is a stipulation of the requestor. This means that no one else should conduct the review in the reviewer's place, and the reviewer should not use, retain, or discuss materials that have not yet been made public.

"Peers who are asked to make judgments about the quality of a proposed or completed project must do their best to determine whether the work they have been asked to review is internally consistent and conforms to the practices of their field of research. This includes: assessing whether the research methods are appropriate, checking calculations and/or confirming the logic of important arguments, making sure the conclusions are supported by the evidence presented, confirming that the relevant literature has been consulted or cited" (Steneck 2007, Assessing Quality).

UGR Keys

UGRs are unlikely to be peer reviewers for publications but may be asked to conduct peer review for drafts and sections of prepublication documents. UGRs should not be intimidated by a mentor or supervisor to provide positive or negative feedback/comments on these materials. The stature of a researcher can sway one's judgment, especially if they are a gatekeeper for the UGR reviewer's next stage of development. If asked to perform this task, UGRs should feel free to apply the same critical eye as a senior researcher or faculty member. In addition, if a UGR observes or is made aware of a breach of confidentiality, they should have the agency to discuss this occurrence with the principal investigator and/or lead researcher.

Conclusion

RCR training and awareness are important for undergraduate students, as they foster a culture of integrity and ethical responsibility, equipping UGRs with the knowledge to navigate complex research environments, understand their rights and responsibilities, and prevent misconduct. Similarly, by adhering to ethical practices in authorship and publication, UGRs can contribute meaningfully to the research community while safeguarding their academic and professional integrity.

The importance of quality mentorship highlights the need to establish supportive relationships that encourage UGRs to seek guidance and advocate for themselves, as there can be a perilous irregularity in the amount and quality of mentorship they are provided. This can have negative ripple effects for the UGR when they work with institutional research support components. However, delegation of mentorship elements to an experienced graduate student can help backfill gaps in knowledge and guidance.

As mentioned previously, familiarity with institutional resources, including offices focused on research integrity and regulatory requirements, will aid in understanding the ethical implications of work involving human and animal subjects, conflicts of interest, and data management. The importance of effective communication and collaboration within research teams is crucial, as it ensures that all members understand their roles and responsibilities. Ultimately, RCR training gives undergraduate researchers the opportunity to build personal confidence within the academic universe and the scientific investigation process and can provide them with a solid foundation to self-advocate.

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